Oil and Gas Possibilities
IN THE
Belton Area

By MALCOLM E. WILSON

Missouri Bureau of Geology and Mines
ROLLA, MISSOURI
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1918

THE HUGH STEPHENS CO.
PRINTERS
JEFFERSON CITY

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LETTER OF TRANSMITTAL.

Rolla, Mo., Jan. 25, 1918.

To the President, Governor Frederick D. Gardner, and the Honorable Members of the Board of Managers of the Bureau of Geology and Mines:

Gentlemen—I have the honor to transmit herewith a brief report upon the geology and structural features of an area in Cass and Jackson counties. This chapter is taken from a more complete report now in preparation giving details of the oil and gas possibilities throughout the State. The interest in the area under consideration and especially the many requests for the map makes it advisable to issue the results of the work in advance of the complete report.

Respectfully,

H. A. BUEHLER,
State Geologist.

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Fig. 1. Map of Missouri showing areal distribution of Pennsylvania series. Dense shading shows outcrop of Missouri group; light shading, outcrop of Des Moines group. As shown on the above sketchmap, the rocks of the Pennsylvanian Series or "Coal Measures" occupy approximately 2,500 square miles of the northern and western portions of Missouri. They consist chiefly of shale, sandstone and thin limestones and have a total thickness of about 1,900 feet. The strata dip chiefly to the north and northwest, commonly 6 to 10 feet per mile and the maximum thickness occurs in the northwest corner of the State. To the east and south they gradually thin until the underlying Mississippian limestones outcrop along their margin. These formations are described in detail in Vol. 13, 2d series, of the reports of this Bureau, entitled "The Stratigraphy of the Pennsylvanian Series in Missouri."

OIL AND GAS POSSIBILITIES OF THE BELTON AREA.

INTRODUCTION.

For many years more or less attention has been attracted to certain areas in the northern and western parts of Missouri due to the discovery of small amounts of oil and gas in a number of the wells drilled throughout that region. Renewed activity in the producing fields of Kansas during the past two years has increased the interest in the possible development of oil and gas pools in Missouri, especially along the western border of the state.

In response to the demands for information regarding the structural and stratigraphic conditions throughout the area underlain by the Pennsylvanian formations this Bureau is preparing a report upon the general oil and gas possibilities throughout the State. The detailed geology of the Pennsylvanian as occurring in each county is well described in the volume entitled "Stratigraphy of the Pennsylvanian Series," vol. 13, (second series). In connection with the preparation of the present report, a number of relatively small areas have been carefully mapped in order to show the general type of structure prevalent in the region underlain by the Pennsylvanian rocks. While the formations show more or less deformation the structures are commonly low and are not as pronounced as some of those in the producing areas of Kansas and Oklahoma. However, structures are found similar to those occurring in the shallow fields of eastern Kansas and are therefore apparently worthy of prospecting. Because the structural features are not of a pronounced type, careful mapping is always advisable before drilling is undertaken.

This report, which deals with an area of approximately 71 square miles located in Cass and Jackson counties, shows a number of low structures worthy of further prospecting. It is issued in advance of the complete report in order that the data may be available at once as much attention has been directed to this particular territory during the past few months.

The mapping has not been extended to the limits of structural conditions. The area lies in the direct line of strike, northeast from the shallow pools of Kansas and no doubt careful mapping will show similar structures along the strike line. As shown on the map a number of small oil and gas wells have been drilled at various points upon the structures, although most of the area is as yet undrilled. Possible variable sand conditions and the presence of faulting and intense folding over a part of the area inject an element of uncertainty as to results.

The mapping was done by detailed plane table traverse on a scale of 4 inches to the mile. A system of control was established in part by precise leveling and in part by careful alidade and stadia traverse. The work was done under the direct supervision of Mr. Malcolm E. Wilson, Assistant State Geologist. Mr. J. S. Brown, Geologist, and Mr. Leslie E. Harlowe, instrument man, carried on the field mapping. The Bureau is indebted to the residents of the district for many courtesies extended during the progress of the work.

H. A. BUEHLER.

GEOGRAPHY AND TOPOGRAPHY.

Location.

The area covered by this report lies in southwest Jackson and northwest Cass counties. It embraces all of Twp. 47 N., R. 33 W., all of Twp. 46 N., R. 33 W. and the northwest portion of Twp. 45 N., R. 33 W. In all, it includes about 71 square miles of territory. The northern border lies less than 6 miles south from Kansas City; the district extends south for 14 miles and is bounded on the west by the Kansas-Missouri line. The principal towns included are Belton, Grandview and Martin City.

The nearest producing oil fields are those near Paola and Rantoul, Kansas, about 30 miles southwest.

Bench Mark and Datum Plant.

An elevation in the town of Belton has been established by the Coast and Geodetic Survey at 1,101 feet above sea level but the exact location of this point was not determined. Therefore an assumed elevation of 1,100 feet above sea level was established at the crossing of the rock road and the Kansas City, Clinton and Springfield railroad in Belton, and this used as the initial bench mark upon which all elevations are based. The elevations of the contour lines on the map, consequently do not express correct altitudes, although approximately so, but show the relative elevations throughout the area of a datum plane or key bed, the base of the Iola limestone, with reference to the assumed bench mark.

Over most of the area it was possible to take observations directly on the base of the Iola but where this was not possible lower limestone markers were used and the elevations raised to the common datum plane by adding a determined correction. Sections of the rock formations were carefully measured in all parts of the district and correction computed from these measurements. Detailed geologic mapping was carried on with the structure mapping.

Just south of the town of Belton an area including a little more than four square miles was found to be too complexly

folded and faulted to allow practical representation on this type of structure map. This complex structure is in part indicated on the map by the dip and strike symbols but no attempt was made to contour it.

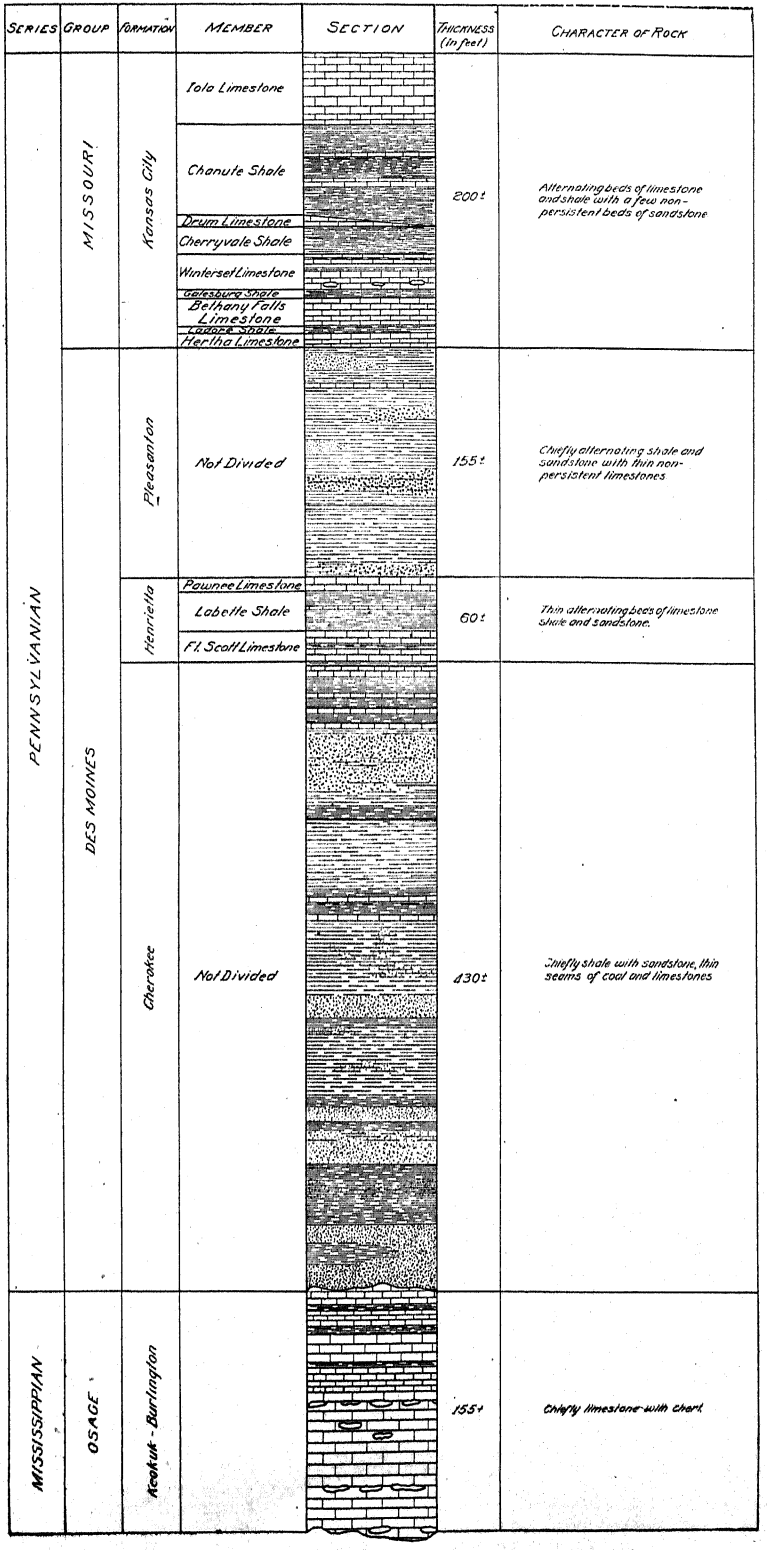
TOPOGRAPHY.

The entire area lies within the physiographic province known as the Scarped Plains and on that part upheld by the Kansas City limestone formation. It occupies the divide between Big and Little Blue rivers on the north and Grand river on the south and as a whole the surface has a slight pitch to the northwest. The general elevation ranges from about 900 feet above sea level in the valley of Big Blue river to 1,125 feet near Belton. Much of the upland lies over 1,000 feet above sea level.

The area is essentially a flat to rolling prairie in which the major stream valleys have been rather deeply cut. Along Big Blue, whose valley deepens and widens notably toward the north margin, a narrow fringe of wooded hills extends back on either side to the prairie upland. Similar strips of hills exist along Little Blue and other streams, though they occupy a very small portion of the area and are reduced in size and importance according to the size of the stream. The resistance of the various outcropping limestones to erosion, however, has caused even the smaller streams to be commonly bordered by low rock ledges and many small but prominent hills with thin limestone cappings occur scattered throughout the area. Open prairie country constitutes by far the greater part of the district.

DRAINAGE AND WATER.

The only stream attaining important size within the limits of the area is Big Blue river which, with its tributaries, drains the northwest part of Twp. 46 N., and most of Twp. 47 N., northward into Missouri river. The tributaries are small though most of them at least contain pools of water throughout the year. Little Blue river drains a portion of the east half of Twp. 47 N. South of Belton the drainage is chiefly southward through small streams tributary to and constituting the head waters of the Middle and East forks of Grand river. Most of these streams also contain at least pools of water throughout the year. Good rock outcrops occur along all the water courses and in places rock forms the floor of the stream beds for short distances.



GENERALIZED COLUMNAR ROCK SECTION.

On the upland, especially surrounding Belton, are many perennial springs which flow out at the base of the Iola limestone. These springs play an important part in the water supply and keep some of the smaller streams alive through the year. Moderate to large supplies of good water are easily available in any part of the area from streams, springs, or shallow wells.

Transportation.

Four railways enter the region: the Kansas City Southern; Missouri Pacific; St. Louis & San Francisco, and the Kansas City, Clinton & Springfield. Belton, Grandview and Martin City are each reached by two lines, Jaudon and Hickman Mills by one.

The country roads are excellent and well distributed. Throughout most of the area they follow section lines and are well cared for. In the Cass county area from Belton north and in the Jackson county district, section lines are not so closely adhered to because of topographic conditions.

GEOLOGY.

Stratigraphy.

Rocks Exposed.—The entire area is underlain by rocks which belong to the Pennsylvanian or "Coal Measures" series and which extend to depths of 650 to 875 feet or more. This series is divided into two groups of rocks classified as the Upper or Missouri group and the Lower or Des Moines group. The outcropping strata belong chiefly to the upper group, but only its lowest formation, the Kansas City, is present. The various limestone members of this formation outcrop conspicuously over nearly all of the area. The lower group is represented by outcrops restricted to the deep valleys in the northern part and only by the highest formation of the group, the Pleasanton shale. The Kansas City limestone formation and the underlying Pleasanton shale are therefore the only two formations of the entire Pennsylvanian series which outcrop in the region and in all about 300 feet of strata are exposed.

Description of Formations Exposed.

Unconsolidated Surface Deposits.—The unconsolidated surface deposits consist chiefly of residual clay mixed with sand

and chert on the uplands and of recent alluvial deposits in the stream valleys. These deposits are everywhere very thin and it is rarely that bed rock lies more than 15 to 25 feet below the surface. Some loess occurs in the north part of the area along the bluffs of the Blues.

Kansas City Formation.

The Kansas City formation is composed of five limestone and four shale members arranged in alternating layers of limestone and shale. One of the shale members, the Chanute, which occurs near the top of the formation, includes two very conspicuous and persistent limestones in this area, which, added to the five prominent ones described as members, makes seven important limestones for the formation. The entire formation is exposed within the limits of the area. Its thickness is variable ranging from 162 to 237 feet, depending chiefly upon the thickening and thinning of the different shale members. The maximum occurs in the southern part of the area where the Chanute shale member alone reached 80 feet in thickness and the minimum in the northern part where this one member is hardly more than 50 feet thick. While all of the members are subject to a variation of thickness, the thickening and thinning is more or less local and in a general way compensating.

GENERAL SECTION OF KANSAS CITY FORMATION.

Name of member.	Thickness of member.
Iola limestone	46 to 53 feet.
Chanute shale, including Raytown and Cement City limestone	50 to 80 feet.
Drum limestone	0 to 5 feet.
Cherryvale shale	15 to 25 feet.
Winterset limestone	18 to 28 feet.
Galesburg shale	5 to 8 feet.
Bethany Falls limestone	18 to 20 feet.
Ladore shale	4 to 8 feet.
Hertha limestone	6 to 10 feet.
Total thickness	162 to 237 feet.

Iola Limestone.

The Iola limestone is the uppermost member of the Kansas City formation and is thus the highest and youngest limestone exposed in the area. Its thickness, where fully present near Jaudon, measured 53 feet, which is believed to be a maximum. Over most of the area of its exposure, the upper part has been removed by erosion, leaving as low as the basal 2 to 5 feet forming benches or cappings on the hills. The Iola is the most widespread and conspicuous limestone outcropping over the upland of the region, thus serving as the most useful marker in determining position relative to the geologic section. Where present it usually forms a cap rock or ledge on the hills or at the top of a slope. Along the Kansas line in Twp. 46 N., however, where the full section is present, it forms bluffs along the streams or appears from the top to the bottom of the slopes. Excellent exposures of the full section may be observed along the road from the river bridge to the Kansas state line in the west part of section 17, Twp. 46 N., or in the Kansas City Southern railroad cut in section 23 and 33, Twp. 46 N.

In texture, color and appearance in outcrop, the beds comprising the Iola are extremely variable. The most common outcrops observed, however, include only the lower beds which are thick, massive, roughly weathered, coarsely crystalline and very fossiliferous layers of a light gray color. These beds are relatively soluble and contain solution cavities or small pot holes often penetrating the full thickness of the layer. The formation is in some places very cherty. Where the upper part has been removed a chert (flint) residue from the eroded portion covers the ground. Nearly all of the numerous large springs of the area flow out at the base of this formation and serve as an excellent marker for this horizon. Near the upper part of the formation are beds having the same peculiar "calico" markings as found in the Raytown limestone described below.

Chanute Shale.

Lying just below the Iola is the Chanute shale, the thickest member of the formation. It consists of an upper, middle, and lower shale, separated by two very persistent limestones, the Raytown and Cement City. The average thickness varies from about 50 to 80 feet chiefly due to the irregularity in thickness of the upper shales. The interval between the Iola lime-

stone and Raytown below it was found to vary from only 7 to over 40 feet. The two upper shales commonly are very arenaceous and in many places grade into an almost pure sandstone. Such was especially found to be the case in that part of the area lying to the south of Belton.

GENERAL SECTION OF THE CHANUTE SHALE MEMBER.

Chanute shale member.

Division.	Thickness.	
Upper shale.....	7 to 40 ft.	Shale blue to blue-gray in places grades into sandstone.
Raytown or "Calico" limestone...	5 to 7 ft.	Fine-grained gray limestone, has peculiar mottled calcite markings and contains very large fossils in top layers.
Middle shale.....	16 to 20 ft.	Shale, gray to black, in places grades into sandstone.
Cement City limestone.....	6 to 12 ft.	Gray, heavy bedded limestone, weathers buff and has dense texture.
Lower shale.....	15 to 25 ft.	Shale, gray to black in part calcareous, contains limestone nodules.

The Raytown limestone, commonly known as the "Calico," is persistent throughout the area. It is easily distinguished by the peculiar mottled appearance of the lower part due to interwebbed calcite markings. These markings together with a brownish to red color stain suggest the calico pattern from which the limestone has derived its common name. The thin upper beds weather to a brown color and contain notably large fossils.

The Cement City limestone has less to characterize it than the Raytown. It is, however, just as persistent and is frequently seen forming a lower bench along the streams beneath the Raytown. Its outcropping beds are buff in color and rough along the exposed face. Several species of cup corals, one of which is very large (Campophyllum Torquium), are most conspicuous members of its fossil content and generally appear wherever outcrops are found. These fossils prove extremely useful in identifying the limestone.

Both the Raytown and Cement City ledges appear commonly in outcrop in the east half of Twp. 46 N., north and south of Belton; in the east half of Twp. 47 N., and along the breaks of the Blues in the north part of the area.

Drum Limestone.

The Drum limestone member lying just below the Chanute shale is not persistent over the area. It occurs chiefly in the Jackson county portion, thinning and practically disappearing to the south. Where observed its thickness did not exceed 5 feet and it consisted principally of a thick massive layer of gray fine-grained limestone which is overlain by thin, partly oolitic beds. The massive layer is known to the Kansas City quarrymen as the "Bull Ledge." The best exposures were found northwest of Grandview along the Big Blue.

Cherryvale Shale.

The Cherryvale shale occupies the interval between the Drum limestone above and the Winterset limestone below. Thus where the Drum limestone is absent a continuous shale horizon extends from the Cement City limestone down to the Winterset. The Cherryvale is variable in character but generally consists of 15 to 26 feet of blue clay shale and black fissile shale, the latter commonly known as "slate." Thin beds of limestone and one or more thin conglomerate pebble beds were observed at a number of localities. This shale is persistent throughout the area.

Winterset Limestone.

The Winterset limestone, just below the Cherryvale shale is an important and persistent member of the formation. It has a thickness of about 18 to 28 feet and outcrops conspicuously in the north and northwest portion of the area. Especially good outcrops occur along the main road leading due north from Martin City to the northern boundary of the township. Two features most important in identifying this member are (1) the abundance of dark blue chert (flint) in the upper beds and large nodules of white chert in the lower beds and (2) numerous shale partings, a few inches to a foot or more thick, separating the layers of limestone in the upper half of the member. The texture of the limestone is commonly dense or fine grained and the color drab to blue.

Galesburg Shale.

The Galesburg shale separates the Winterset from the Bethany Falls limestone below. This shale is only 5 to 8 feet thick and consists of an upper and lower gray clay shale separated by a black bituminous fissile shale or "slate." This is one of the thinnest shale members in the formation.

Bethany Falls Limestone.

The Bethany Falls limestone or "mottled lime" as it is commonly called, is the best known and probably the most easily distinguished member of the formation. It is essentially an escarpment and bluff former composed chiefly of white to light gray massive limestone. The upper few feet, however, are thin bedded, and weather into rounded blocks having a nodular surface. This upper fine-grained portion has a mottled gray appearance which gives the member its common name. A well-defined system of jointing along which weathering proceeds rapidly is responsible for loose blocks, not uncommonly large masses of the limestone detached from the main ledge, occurring along the line of outcrop.

The Bethany Falls maintains a thickness of 18 to 20 feet over the entire area. It is only exposed in the extreme northern portion along the valley of Big Blue river and its tributaries.

Ladore Shale.

The Ladore shale, separating the Bethany Falls from the Hertha limestone below is a persistent member but was not observed to exceed 8 feet in thickness where outcropping in the area. Its composition is variable, consisting mostly of shale with thin limestone seams near the middle. The lower portion contains a rather persistent band of black "slaty" shale, observed wherever the outcrop was found. In places the Ladore is very sandy and in part grades into an almost pure sandstone.

Hertha Limestone.

The Hertha limestone or "chocolate rock" is the basal member of the Kansas City formation and rests on the Pleasanton shale below. Weathered exposures are buff to reddish brown in color though the unweathered limestone is gray. The outcrops

are restricted to the Big Blue valley in the extreme northern part of the area where the member is 6 to 10 feet thick. It is known, however, to be a very persistent member of the formation.

Pleasanton Shale.

The Pleasanton shale lies below the Kansas City formation and appears in outcrop only in the valley bottom of the Big Blue north of Martin City. The formation has a thickness of 150 to 180 feet of which the upper part alone, not to exceed 40 feet, is exposed. These beds are composed chiefly of shale, commonly very sandy and in places grading into beds of sandstone. The entire formation consists of alternating beds of shale and sandstone of irregular extent and thickness with local beds of sandy limestone near the top and calcareous sandstone near the bottom. It cannot be differentiated into members because of the nonpersistent and changeable character of the beds.

Unexposed Beds to Be Penetrated in Drilling.

In testing for oil and gas interest centers chiefly in the buried rocks not exposed within the area described. These rocks, however, are exposed to the east and southeast of the region in adjacent territory and on the slopes of the Ozark dome and have been penetrated to a considerable depth by deep wells in both Jackson and Cass counties. Their character is therefore not unknown and they can be described in considerable detail. Many of the Jackson and Cass county wells have been carried to the base of the Pennsylvanian deposits but very few have penetrated the still deeper strata. The deep Raytown well located about 6 miles northeast of the area, however, was sunk to the granite floor, a depth of 2,346 feet, and the log is printed below for reference.

Two unexposed formations of the Pennsylvanian series underlie the area beneath the Pleasanton shale. These are the Henrietta and Cherokee formations. The Cherokee is the lowest, and rests directly upon the Mississippian limestones. Once this formation is entirely penetrated, the ordinary test for oil and gas is generally considered complete in this region. A test well for oil and gas which is carried to any considerable depth below the base of the Pennsylvanian beds in eastern Kansas or western Missouri, is commonly described as a "deep test."

HENRIETTA FORMATION.

Wells passing through the Henrietta formation in western Jackson and Cass counties have found it to be 40 feet to 60 feet thick. It consists of three members, a limestone above and below separated by a shale. The upper limestone is the Pawnee, the lower the Ft. Scott, or as it is commonly called, the "Oswego lime." Both limestone members contain shale beds which are of variable thickness and may constitute a greater part of the members than the limestone. The section from 268 to 324 feet in the Raytown well, illustrates the general character of the Henrietta formation in western Jackson county.

CHEROKEE FORMATION.

This formation generally known as the Cherokee shale, underlies the area with a thickness of probably 375 to 450 feet. The Cherokee contains most of the important oil and gas "sands" of the Mid-Continent field and in it largely rests the hopes for producing wells in the area discussed. Such oil as has already been found has been obtained chiefly from the upper 50 to 100 feet of this formation, but gas sands occur as high as the middle of the Pleasanton.

The Cherokee is composed essentially of shale with a lesser but large amount of sandstone and contains a few thin beds of limestone and seams of coal. The formation changes in detailed character from one locality to another and is so variable that no attempt has been made to subdivide it into members. Drill records of the Cherokee in two nearby localities may be entirely dissimilar in detail but similar in both showing a thick section of chiefly shale and sandstone. The sandstone beds vary in thickness from a thin seam to over 50 feet and may occur distributed from top to bottom in the formation. Commonly they are more plentiful in the lower half. They may occur as beds persistent over a considerable area, as lentils or as patches. The beds may grade laterally into shales and the lentils pinch out within very short distances. The sandstones are almost as variable in lithologic character as in method of occurrence though they are composed chiefly of medium to fine grained, angular, quartz sand, generally micaceous. The grains may be cemented into an extremely hard "sand" but such is not commonly found to be the case.

All of the wells entering the Cherokee shale in the area under discussion have penetrated "sands" in the upper part of the formation which, according to the drillers' records, vary from a few to 27 feet thick. In the Raytown drilling four different sandstones were found in the formation. It is, however, impossible to correlate the sandstones found in the different wells though it appears that sandstone beds are prevalent at certain horizons in the formation. The important consideration is that sandstones are almost sure to be encountered in drilling and that most of these are at least capable texturally of forming oil and gas reservoirs.

Mississippian and Lower Beds.

At the base of the Pennsylvanian strata 650 to 875 feet or more below the surface, the thick cherty (flinty) limestones of the Mississippian series are entered in drilling. Many deep wells in western Missouri have penetrated 250 to 375 feet of these beds and they may be found in this area to have a still greater thickness. When the drill passes from the Pennsylvanian beds into these limestones they are easily identified by the great thickness of limestone with but few or no shale "breaks," by the exceptional amount of chert and the coarsely crystalline character of the limestone observed in the drillings. The crystalline, cherty limestones, compose the Burlington-Keokuk formations of the Mississippian series and overlie, if present, the more shaley, impure limestone of the Kinderhook formation.

The beds to be penetrated below the Mississippian to the granite floor consist chiefly of magnesian limestones or dolomites with several sandstones which constitute a very minor part of the section relatively speaking. The sandstones are chiefly of early Ordovician and Cambrian age and are not considered as possible oil or gas horizons in this area.

There is very little information available on the details of the rock section to be penetrated below the Mississippian beds in this area. From such data as are available, however, there seems to be no doubt but that the Devonian and Silurian strata, which should normally occur between the Mississippian and Ordovician rocks, are entirely absent. The drill in reaching the base of the Mississippian will probably enter beds just below not younger than Ordovician and possibly of Lower Ordovician age. The general absence of the Devonian and Silurian rocks on the west and northwest flanks of the Ozark Dome has been fairly well established.

RECORD OF STRATA IN CORE DRILLING NEAR RAYTOWN.*

Stratum.	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Pennsylvanian series:				
Kansas City formation:				
Chanute and Cherryvale shale:				
Shale, light, calcareous	32		32	
Limestone	2		34	
Shale, blue	17	6	51	6
Winterset limestone:				
Limestone	15	3	66	9
Galesburg shale:				
Shale, slaty	3	2	69	11
Bethany Falls limestone:				
Limestone	22	9	92	8
Ladore shale:				
Shale, slaty	4	7	97	3
Hertha limestone:				
Limestone	15		112	3
Pleasanton formation:				
Shale, some parts gritty	94	9	207	
Coal		2	207	2
Shale, some parts gritty	61	3	268	5
Henrietta formation:				
Limestone	8	7	277	
Shale, slaty	11		288	
Limestone	4		292	
Slate		10	292	10
Coal	1	6	294	4
Fire clay, hard	5	8	300	
Limestone	5		305	
Shale, slaty	14	2	319	2
Limestone	4	3	323	5
Cherokee shale:				
Slate	1	1	324	6
Coal, Slate, Coal (Lexington)	1	2	325	8
		8	326	4
		9	327	1
Limestone	12	9	339	10
Shale	12	2	352	
Limestone, hard ("Rhomboidal")	3	6	355	6
Slate, black	3		358	6
Coal (Summit)	1	3	359	9
Fire clay	2	7	362	4
Limestone	7	1	369	5
Shale	4		373	5
Limestone	4	3	377	8
Slate	3		380	8
Coal (Mulky)	1		381	8
Fire clay	5	8	387	4
Sandstone	11	10	399	2
Sandstone, streak of slate or shale	32	3	431	5
Shale, slaty	15	4	446	9
Slate and shale	5	6	452	3
Coal (Bevier)	1	8	453	11
Shale and slate	49		502	11
Slate	6		508	11
Coal	1	4	510	3
Limestone	8		518	3
Slate and shale	6		524	3

*Ten miles southeast of Kansas City (sec. 7, T. 48 N., R. 32 W.). Drilled in 1886. Record furnished by S. J. Hatch.

RECORD OF STRATA IN CORE DRILLING NEAR RAYTOWN—Continued.

Stratum.	Thickness.		Depth.	
	Ft.	*in.*	*Ft.*	*in.*
Pennsylvanian series—Continued.				
Cherokee shale—Continued.				
Coal		10	525	1
Limestone	18	6	543	7
Sandstone, showing of gas	16	2	559	9
Shale, sandy	23	2	582	11
Shale, sandy, micaceous	37	7	620	6
Shale, sandy, streaks of slate	33	2	653	8
Sandstone	15	7	669	3
Shale, sandy	24		693	3
Shale	15		708	3
Sandstone, coarse, salt water	43	9	752	
Mississippian series:				
Burlington-Keokuk:				
Limestone, shelly in places, with shale partings	73		825	
Limestone, light-colored, flinty layers	260		1085	
Kinderhook group (?):				
Limestone, dark, with shelly layers	100		1185	
Sand, dark-reddish	15		1200	
Ordovician:				
Joachim (?)*:				
Limestone, bluish, fine-grained, shelly in places	57		1257	
St. Peter:				
Sandstone, white at top, reddish at bottom	64		1321	
Cambro-Ordovician:				
Limestone, gray and brown	129		1450	
Limestone, shelly and clayey	10		1460	
Limestone, light, coarse, and porous	160		1620	
Limestone, shelly	20		1640	
Sandstone, white	16		1656	
Limestone, light, flinty, porous, water disappeared or was lost	74		1730	
Limestone, gray, clayey, and sandy	20		1750	
Limestone, gray, hard, fine-grained	70		1820	
Sandstone, gray, hard, fine-grained	15		1835	
Limestone, gritty, porous, crystalline, in places white and flinty	215		2050	
Sandstone, hard, coarse	50		2100	
Cambrian:				
Limestone, with seams of gray and brown shale	40		2140	
Limestone, dark and light, fine-grained	110		2250	
Sandstone, hard, coarse	98		2348	
Proterozoic:				
Granite	53		2401	

*Correlation below 1,200 feet by E. O. Ulrich, U. S. Geol. Survey Water-Supply Paper 195, p. 86, 1907.

STRUCTURE.

General Statement.

It is generally conceded that certain geologic structural features are necessary for the accumulation of commercial quantities of oil and gas. These features are brought about chiefly by the folding of originally flat-lying beds of rock to form upward folds called anticlines, domes, monoclines, or terraces, and depressed folds called synclines. The anticline is a very common type of upward fold. It may be described as an elongate fold in which the strata dip downward on both sides from an axis or from the crest of the fold. The fold dies away on either end and is usually roughly elliptical in outline, though its shape may be very irregular. When the axis becomes so shortened as to give the fold a more or less circular outline or where the strata dip downward on all sides from a central point, the structure is commonly called a dome. A monocline is a single fold in the strata producing a dip in one direction with no reversal of dip. The area over which the rocks dip gently or lie almost flat extending away from the upper edge of a monoclinal fold may be called a terrace. Common usage of the terms anticline, dome, monocline, and terrace in the oil fields has given each a somewhat arbitrary definition.

The layman interested in oil geology makes common use of the term structure but it is apparent that many misconstrue the meaning of the term. One of the most widespread erroneous views is that where rocks are arched up into anticlines or domes; these should always appear as such at the surface and form hills corresponding to the size and shape of the structure. This is, of course, sometimes the case but more commonly erosion has so altered the surface features originally produced by the folding that the top of an anticline or dome may even occupy a topographic valley or lie on the slopes of such. So the rock structures and topography may bear no discernable relation to each other and this is especially true in a region where the folds are relatively low as in the area described.

Briefly the principals underlying the accumulation of oil and gas in commercial quantities may be summed up as follows:

1. There must be a source and collecting area from which a considerable amount of oil can be drawn. Originally, the oil is disseminated sparcely over a wide area and is collected into pools by migration to some favorable place of accumulation.

2. There must be porous beds through which the oil can migrate to a favorable place of accumulation and which form a containing reservoir at this place. These beds are most commonly sands, sandstones, or porous limestones.

3. A practically impervious bed above the oil-bearing rock and under some conditions below, must be present to prevent escapage. Such beds are commonly but not necessarily shale or clay.

4. A favorable place for accumulation where the oil comes to rest or is trapped is a most important requisite. Without such a place there could be no accumulation. Where the oil rocks are saturated with water, accumulation of the oil and gas will take place underneath anticlines, domes, monoclines, terraces; where the oil stratum contains but little water or is dry, the downward folds or synclines may be more favorable for accumulation.

5. Water is a most important agent affecting oil accumulation. Oil being lighter than water, will rise above it, travel up the dip of the rock, if saturated with water, and come to rest under upwarped folds. If the beds containing the oil are not saturated with water the oil can rise only to the water level and may come to rest on the flanks of a fold. If there is no water at all in the beds to carry the oil up it may accumulate in the lowest part of a trough or syncline.

6. As gas is lighter than oil and oil in turn is lighter than water, where all three are present beneath a structure they should occur in descending order, gas, oil, and water, according to their respective gravities. Under ideal conditions this is always true, but complexities of structure and "sand" conditions may destroy this arrangement.

Structural Features of the Area.

The regional dip of the rock beds in Cass and Jackson counties is in a northwest direction, off the flank of the Ozark dome. This dip is, however, very low, the average across Jackson county being only from 6 to 10 feet in a mile and across Cass county it is probably very similar. To the southeast for 40 or 50 miles toward the crest of Ozark dome it becomes only slightly increased. In the area described the general regional dip has been disturbed by crustal movement producing a number of low anticlines, domes, monoclines, terraces, and synclines, some of which merit consideration with reference to oil and gas

possibilities. With the exception of one relatively small area, the folding has not been great and in only a few localities aside from the excepted area, do the rocks have sufficiently steep dips to be easily observed by the eye. There is very little discernable relation between the topography and the general structural features of the area.

For nearly the entire distance along the west side of the area there is a general though deviating, westerly dip of 30 to 40 feet to the mile and this dip exceeds the regional dip of west Missouri by 25 to 30 feet to the mile and is greater than the regional dip immediately west, in eastern Kansas. It forms the west flank of three well defined anticlines which lie chiefly on the more complexly folded area to the east. These anticlines are separated from smaller anticlines by shallow saddle-like depressions of varying widths. In the north half of the area synclinal depressions occur, one of which just east of Hickman Mills, is especially deep.

The most important structures of the area are anticlines, irregular in outline and whose crests rise from 15 to more than 40 feet above the separating synclinal depressions. The terraces present are small and probably, as structures, are of minor importance. Such domes as occur form high points on the anticlines and need not be mentioned separately.

Details of Structural Features.

Belton Anticline.

The largest and probably the most important anticline within the area lies in the northeast part of Twp. 46 N., and extends northwest barely into the south central sections of Twp. 47 N. It is called the Belton anticline because of its location relative to the town of that name in northwest Cass county. The crest of this anticline may be said to pass in a northwest direction from the center of section 24, Twp. 46 N., through the SW. ¼ of section 13, thence to the northwest corner of section 14 where it swings to the north across section 10 and enters section 3. The structure is narrow and sharply defined at the southeast end but widens rapidly to the northwest, the outline being roughly suggested by the 1,050-foot contour line. On the north across sections 3 and 7, Twp. 47 N., the north dip is 50 feet. On the west, from the west part of section 10 through section 9, the west dip is 60 feet. The northeast flank dips less

steeply, though the fall is 30 feet in a northeast direction across section 2. On the east, across sections 11 and 12, the east dip is 30 feet, and across section 13 is 40 feet. On the southwest flank at least 15 feet of south dip was observed in sections 14 and 15, just north of an area too highly folded and faulted to be practically mapped. The Belton anticline thus, is a completely closed structure with well defined dips of 30 to 60 feet on all sides except the southwest where the structure is encroached upon by a complexly folded and faulted area. The highest point on the structure is located on the Williams farm in the SE. ¼ of section 10, Twp. 46 N., where the vertical deformation is about 60 feet. About 2 square miles of area is included by the 1,060-foot contour line and over 4 square miles by the 1,050-foot contour. The area which appears structurally favorable for testing is much greater, however, as discussed later.

Faults.—Aside from the faulted area encroaching upon the southwest flank of the anticline and discussed in a later paragraph there appears to be a small fault or perhaps series of faults on the structure roughly following the east-west road between sections 10 and 15. There are few outcrops in this locality, not enough to follow the direction of the fault plane or, in fact, to determine with certainty the true significance of the conditions. The evidence of some faulting, however, seems clear enough. An outcrop near the Williams' house (SW. ¼, sec 10) on the north side of the road shows the basal layers of the Iola limestone lying practically flat at the 1,080-contour elevation. Just across the road to the south and a little west the same beds appear about 20 feet lower and dipping at an angle of 30° in a direction south 8° west. A few yards farther south the same beds appear with approximately the same dip in the same direction. The vertical displacement cannot be great and it is possible that it does not seriously effect the deep lying beds, if at all. Still in view of the lack of more critical evidence this disturbance of the strata deserves consideration relative to future testing.

The Jaudon Anticline.

The Jaudon anticline lies just to the east of Jaudon in the extreme southern part of the area mapped. It extends from about the southern border of the area in sections 9 and 10, Twp. 45 N., northward through sections 33 and 34, T. 46 N., abutting at the north end into the area of complex folding and

faulting. That part of the structure elevated above the 1,050-foot contour line covers an area of about 4½ or 5 square miles. The anticline is slightly saddle shaped; the two more elevated portions at the north and south constituting low domes being separated by a slight sag in the east central part of section 4, Twp. 45 N. The west and east sides of the anticline are especially well defined the dip on either side being about 30 to 35 feet in a mile. The north flank about 10 to 20 feet below the highest closed contour line (1,070-foot contour) is cut by a zone of faulting running in an east and west direction across the southern parts of sections 27 and 28, Twp. 46 N. On the southeast folding extends beyond the area mapped.

Minor Structures.

Anticline Centering in Sec. 9, Twp. 47 N.—In the northwest part of Twp. 47 N. is a low anticline the highest part of which lies chiefly in section 9. This section is crossed by Big Blue river and has a very broken surface on either side of the river valley. The west dip in section 8 just west of the crest, is 40 feet. From the highest closed contour line (the 1,000-foot contour) the east dip varies from about 20 feet in a mile across section 10, to 50 feet across section 3. The north and south dips across section 4 and 16, respectively, are very gentle; not greater than 10 or 15 feet to the mile. The accentuated east dip across section 10 is due to the presence of a relatively deep syncline in sections 2 and 3.

Anticline Centering in Sec. 26, Twp. 47 N.—In section 26, Twp. 47 N., chiefly, is a very low anticline, the top of which has been arched up 10 to 20 feet above the surrounding depressions. This structure is separated on the southwest from the Belton anticline by a saddle of very shallow depth. On the northwest it rises from an area where the rocks lie almost flat. The major axis runs in a southeast to northwest direction.

This anticline, with those already mentioned, constitutes what appears to be the most locally important upwarped folds in the area. However, in sections 13 and 24, Twp. 47 N. and in section 1, Twp. 46 N. there is evidence of folding which may be of importance, especially in the area to the east. Also in sections 19, Twp. 47 N., on the west edge of the area there is a slight east dip which probably signifies the presence of an anticlinal fold to the west.

Faulting and Complex Folding.

Faulting associated with extremely complex folding of the rocks occurs in that portion of the region including most of the area in sections 22, 23, 26, 27, Twp. 46 N., just southwest of Belton, and some portions of adjoining sections. In this area crustal disturbance has produced conditions so complex as to prohibit practical representation by the methods used in constructing the accompanying structure map. Although the evidence in hand is not as complete as is to be desired, there seems to be no question but that the faulting here is the result of compression producing a number of very sharp folds along which cleavage and displacement of the rock beds took place. At least two well defined zones of faulting can be traced for short distances, one in a general east-west direction across the southern portion of sections 26 and 27, and a second in a general north and south direction across section 23. Aside from these zones there is little or no system to the direction of dip of the steeply inclined beds. The displacement along the fault zones is not great, probably nowhere exceeding 75 feet, and not exceeding 50 feet at any point observed. In places the breaking of the rocks along the sharp folds took place with little or no vertical displacement, at other points it was accompanied by small vertical movement. The folds die out in short distances. So far as could be determined the area affected to any important degree is apparently restricted to within the limits mentioned above.

Just how deep the faulting extends or what its affect may be on the beds several hundred feet below, cannot be stated. Since the vertical movement at the surface along the faults is small, it seems hardly probable that they should be affective to any considerable depth, though distortion produced by the folding may carry to the deep underlying beds. Faulting in an area usually tends to decrease the probability for oil accumulation in as much as the breaking of the rock beds opens avenues of escape for the oil. This, however, is not always the case and it is probable that, under the circumstances, the faulting in this area does not seriously affect the possibilities of accumulation, at least, under the major portion of either of the two anticlines bordering the faulted area.

Relation of Structural Features of the Area to Possible Accumulation.

The several anticlines contained within the area are all very low and small as compared to some of those producing oil and gas in Kansas and Oklahoma. To some it may even appear that these folds are altogether too low to be of any great importance. Still in that part of eastern Kansas underlain by the same formations and where the depths to the "sands" are about the same as is to be expected in the Belton area, structures of less size and vertical deformation have proven very productive. In fact some of the productive eastern Kansas structures are much smaller and have much less vertical deformation than the Belton or Jaudon anticlines. It has furthermore been illustrated by the small oil and gas wells of this and other areas in Jackson, Cass, and adjoining Missouri counties that prominent structural conditions are not required for some accumulation. In this area both fuels have been found in small quantities and gas is now being obtained at relatively shallow depths where there is very little if any evidence of surface structure. Some of this accumulation, however, is probably due to irregular "sand" conditions. It appears therefore that the more prominent anticlines at least, of the Belton area are sufficiently good structurally to produce very favorable conditions for accumulation.

Aside from structural features, the sand conditions must be especially considered in this area. They may prove of equal or even greater importance than the structure itself. Over the area as a whole, the Cherokee "sands" to be encountered are known to be of extremely variable thickness, some of them undoubtedly lenticular in shape, others probably pinch out locally or grading laterally into shale. In this respect, the area may be comparable to portions of the Paola-Rantoul field. It is well recognized that with such sand conditions accumulation may be brought about and controlled irrespective of structure and this may be either locally or generally the case.

Previous Test Drilling—Gas.

Belton.—Between the years 1902 and 1906 about 15 test wells were sunk in sections 1, 2 and 14, Twp. 46 N., in the vicinity of Belton. Most of these wells range from 295 to 400 feet deep, several are between 400 and 550 feet deep; one well was sunk

to a depth of 672 and the deepest test reached a depth of 820 feet. The wells may be divided into two principal groups, one located in section 14, just west of Belton and the other about one and one-half miles north in section 2. The Rozier and Wilson tests are located in NE. ¼ and SW. ¼ of section 1, respectively. In nearly every well gas is reported to have been encountered at various depths between 280 and 665 feet and from most of the wells showings of small quantities of oil are reported. From the logs of several of the wells available for study, it is clear that the first gas sand occurs near the middle of the Pleasanton formation a little less than 100 feet below the top. In 4 wells starting in the Iola limestone this sand was reached at depths of 282 to 295 feet. It varies in thickness from 10 to 29 feet and from it is derived most of the gas piped into Belton from the wells just west and north of the town. Several of these wells were bottomed just below it. The initial gas pressure from this sand varied from 60 to 85 pounds. Below this sandstone about 20 feet, wells Nos. 4 and 5 of the Belton Gas Company encountered a second gas sand in the Pleasanton. It is reported, however, to have been less productive than the first sand. The next important gas horizons below those just mentioned occur in the Labette shale member of the Henrietta formation. Practically all of the wells penetrating the Henrietta in this area have found some gas in the lenticular sandstones or bituminous "slates" in the Labette shale though this shale has apparently not furnished any very important supplies. The gas horizons in the Henrietta have been reached from wells starting in the Iola limestone at depths of 390 to 425 feet. The most productive gas sand was found in the Cherokee shale. Well No. 4 of the Belton Gas Company reached 7 feet of coarse pebbly sand at a depth of 665 feet, from which a pressure of 180 pounds was recorded. The sand lies 190 feet below the top of the Cherokee and is the deepest gas sand yet encountered in the drilling around Belton. Other gas sands were found in the upper 100 feet of the Cherokee, at depths of 460 to 540 feet, but their importance as producers could not be learned.

The Belton wells in section 14, just west of town all start in the Iola limestone, those north of town start at horizons near the top of the Chanute shale or higher, depending upon the topographic elevation. The deepest well, 820 feet in depth, is reported by Mr. Geo. Scott of Belton to have entered what he believed to be the Mississippian limestone at the base. The

well, located in section 2, north of Belton, started in the Iola limestone reaching the top of the Cherokee shale at a depth of 455 feet. Its base is thus 365 feet below the top of this formation and the last 5 feet of cuttings are reported as "sandy lime." It is believed that this well is bottomed in the lower part of the Cherokee and did not reach the Mississippian. However, the Mississippian would probably have been reached in less than 100 feet of additional drilling and possibly in less than 50 feet.

For a number of years after the installation of pipe lines through the town, about 75 residences were supplied abundantly with gas of excellent quality for both lighting and heating. About 50 residences were supplied by the wells west of town operated by Mr. Geo. Scott and 25 by the wells north of town operated by Mr. A. D. Goodbar. Later, salt water entered the sand in the productive areas, slowly overcame the gas pressure and caused a gradual decrease in production. At present less than a dozen residences are being supplied.

The following logs submitted by Mr. C. M. Mahan indicate the nature of the strata penetrated and the depth to the gas sands in the vicinity of Belton.

RECORD OF SCOTT & MARSH WELL NO. 1.

(NE. ¼, Sec. 14, T. 46 N., R. 33 W.)

Stratum.	Thickness.	Depth.
	Feet.	*Feet.*
Recent:		
Soil	12	12
Pennsylvanian:		
Kansas City formation:		
Lime (Iola limestone)	5	17
Gumbo	13	30
Red rock	10	40
Lime	17	57
Red rock	5	62
White sand	30	92
White slate	10	102
Lime	38	140
Pleasanton formation:		
White shale	5	145
Blue lime	40	185
White slate	40	225
Water sand	10	235
White slate	47	282
GAS SAND	10	292

RECORD OF BELTON GAS COMPANY WELL NO. 3.

(SE. ¼, Sec. 2, T. 46 N., R. 33 W.)

Stratum.	Thickness,	Depth,
	Feet.	*Feet.*
Recent:		
Soil	5	5
Joint clay	7	12
Pennsylvanian:		
Kansas City formation:		
White lime (Iola limestone)	10	22
Blue shale	5	27
Red shale	10	37
Blue lime	20	57
White slate	10	67
White lime	3	70
Blue slate	5	75
White sand	15	90
White slate	20	110
White lime	40	150
Black slate	5	155
White lime	15	170
Black slate	5	175
Water (175)	.....	.....
Blue lime	15	190
Pleasanton formation:		
White shale	92	282
TOP OF GAS SAND (282)	.....	.....
GAS SAND	12	294
GAS SAND	17	311
Black slate	4	315
White slate	30	345
White sand	10	355
White slate	10	365
White lime	8	373
Henrietta formation:		
White shale	7	380
Blue lime	15	395
White shale	5	400
Black slate	6	406
Blue lime	7	413
Black slate, water and GAS	5	418
GAS SAND	7	425
White slate	5	430
Sand and lime	10	440
Dark slate	3	443
White slate	7	450
Lime	5	455
Cherokee formation:		
White slate	20	475
OIL SAND	15	490
Shale, white	15	505
Black shale	25	530
GAS SAND	15	545
Black slate	10	555
Flint lime	5	560
White slate	40	600
Black slate	40	605
White slate	35	640
Set 6¼ casing	.....	.....
White slate	10	650
Dark slate	50	700

RECORD OF BELTON GAS COMPANY WELL NO. 3—Continued.

Stratum.	Thickness.	Depth.
Pennsylvanian—Continued.		
Cherokee formation—Continued.	*Feet.*	*Feet.*
GRAY OIL SAND, small showing	35	735
White slate	20	755
OIL SAND	10	765
White shale	15	780
Sand and salt water (780)	.....	.....
OIL SAND	25	805
Black slate	10	815
Sandy lime	5	820

Most of the wells west of Belton in the NW. ¼ of section 14 are located on the crest of the Belton anticline and within the area enclosed by the 1,060-foot contour line. The three best wells north of town are situated on the northeast flank of anticline between the 1,045 and 1,050-foot contours. In this connection it is of interest to note that the Mastin oil wells about 1 mile north of the last mentioned gas wells are located still lower structurally, between the 1,005 and 1020-foot contours.

Martin City.—In 1908 Mr. Louis H. Knocke drilled 5 wells for gas near Martin City in or near the SE. ¼, Sec. 20, Twp. 47 N. The deepest drilling was carried to a depth of about 550 feet and ended 290 feet below the top of the Cherokee shale. Gas was encountered at several horizons in each well and some oil was found. The first gas sand encountered was found in the Pleasanton shale at a depth of 150 feet and the second sand either at the base of the Henrietta or the top of the Cherokee at a depth of 250 feet. The first important producing gas however, occurs in a sandstone lying about 25 feet below the top of the Cherokee and only 5 to 10 feet thick. It is reached in the wells which start a little above the Bethany Falls limestone, at a depth of about 275 feet. Other gas sands affording stronger pressures lie deeper in the Cherokee. Concerning the sands Mr. Knocke states: "I am using only the top gas now which is 274 feet deep with a pressure of 65 pounds; the better ones are below. One at 350 feet gives a pressure of 105 pounds, one at 435 feet, 108 pounds; and the last one struck at 522 feet gave a pressure of 187¼ pounds. The man who tested the 522-foot gas said it made 1,580,000 feet per day." The sand at 435 feet contains considerable oil which Mr. Knocke reports to be heavy and thick and which fills the wells so as to interfere with the gas flow.

Three of these wells, using only the 275 foot sand, supply the town of Martin City with heating and lighting gas, at the rate of 160,000 to 642,000 cubic feet per month. Any one of the wells could easily satisfy this demand.

These wells are located on a small terrace or between the 975 and 985 foot contour lines. A low fold extending in a general east and west direction slightly elevates the rocks in the locality.

15. RECORD OF WELL OF L. H. KNOCKE.**
(SE. ¼ Sec. 20, T. 47 N., R. 33 W.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Soil	13	13
Gravel	5	18
Pennsylvanian:		
Kansas City formation:		
Limestone, gray (Bethany Falls)	14	42
Shale	5	37
Limestone	1	38
Shale	5	43
Limestone (Hertha)	12	55
Pleasanton formation:		
Shale, light	40	95
Limestone, shelly	10	105
Shale, dark	40	145
GAS SAND	5	150
Shale, light	15	165
Shale, dark	5	170
Shale, light	15	185
Shale, red	5	190
Shale, dark	32	222
Henrietta formation:		
Limestone	5	227
Shale	2	229
Limestone	5	234
Shale	4	238
Limestone	7	245
Limestone, hard	2	247
Limestone	3	250
Cherokee shale:		
GAS SAND	7	257
Shale, dark	10	267
Limestone	5	272
GAS SHALE, hard, bituminous	4	276
OIL SAND	5	281
Shale, white, sandy	32	313
Limestone	5	318
Shale, dark	20	338
OIL AND GAS SAND	27	365
Shale, dark	23	338
OIL SAND	14	402
Shale, dark	71	473
Shale, light	10	
Shale, dark	12	
Coal	7	
Shale, dark		
Shale, light		
GAS SAND		

**This is a producing well.

OIL.

A group of 8 wells was sunk about 15 years ago 2 to 3 miles north of Belton on the old Mastin Ranch (now Scruggs and Johnson Ranch) chiefly in the W. ½ of Sec. 36, Twp. 47 N. These wells ranged in depth from about 350 to 500 feet; drilling started near the base of the Chanute shale and the wells were bottomed at various depths in the Cherokee shale. In every well oil, and in some gas, was encountered in a sandstone about 6 feet thick, occurring in the upper 100 feet of the Cherokee. The oil sand was encountered in all the wells so far as known between 350 and 400 feet in depth. In well No. 7 it was struck at a depth of 373 feet. One or two wells were sunk about 100 feet deeper in search of lower "sands." In 1909 five of the wells were put on the pump, giving a production of about 300 barrels a month, each well when kept cleaned supplying about 2 barrels a day according to Mr. L. E. Mahan, who at that time owned the property. At present the wells are abandoned but the group is the most important set of oil wells yet drilled in Missouri.

The production was a high grade lubricating oil which sold at the wells in 1902 for $3 a barrel. Following is the analysis.

ANALYSIS OF OIL FROM MASTIN RANCH WELLS.*

Constituent.	Per cent.
Light oil between kerosene and gasoline	10
Burning oil (kerosene)	19
Lubricating oil with paraffin base	53
Residum, consisting of 10 per cent tar and 8 per cent paraffin with only trace of inorganic matter	18
Total	100

*Analysis from U. S. Geological Survey, Mineral Resources, 1902, p. 566. Made by Prof. Frankforter, University of Minnesota.

Structurally the "Mastin Ranch" oil wells are located at the very base of the Belton anticline on its northeast flank between the 1,005 and 1,020-foot contour lines. More generally considered, they are even in the shallow syncline between the Belton anticline and the low structure centering in section 26 just to the north.

9. RECORD OF WELL OF SCRUGGS & JOHNSON (MASTIN NO. 7)

(W. ½ NW. ¼ Sec. 36, T. 47 N., R. 33 W.)

	Thickness.	Depth.
Pleistocene and Recent:	*Feet.*	*Feet.*
Soil and clay	10	10
Pennsylvanian:		
Limestone	5	15
Rock, red	10	25
Shale, blue	10	35
Limestone	10	45
Shale, blue	46	91
Limestone	33	124
Shale, bituminous, water	5	129
Shale, dark	100	229
Limestone	76	305
Shale, light	50	355
Shale, bituminous, water	5	360
Limestone	2	362
Shale, green	11	373
OIL SAND	6	379

At three other points within the area wells producing some oil have been sunk. The Rozier well in the NE. ¼ of Sec. 1, Twp. 46 N. is situated about 1 mile southeast of the Mastin wells. This well was similar to the Mastin wells, producing a small yield of high grade lubricating oil possibly from the same sand. The well is located structurally higher, about 30 feet, and was started a few feet above the Raytown limestone, making the depth to the sand probably a little greater at this point. Oil was sold locally from this well for some time but it is now abandoned. Some oil was also obtained from one of the Goodbar wells north of Belton in Sec. 2, Twp. 46 N. Mr. Goodbar reports a production of about 100 barrels a year secured from a well in which the water and oil had overcome the gas pressure. The oil was skimmed from the top of the water after pumping.

The C. M. Mahan well, in the NW. ¼ of Sec. 14, Twp. 46 N. on the west edge of Belton was drilled about 15 years ago and still produces a small flow of oil, gas and water. This well is reported to be 425 feet deep. The oil observed is dark and heavy and not used; the gas supplies the Mahan residences for lighting and heating.

RECORD OF ROZIER WELL.

(NE. ¼, Sec. 1, T. 46 N., R. 33 W.)

	Thickness.	Depth.
	Feet.	*Feet.*
Pleistocene and Recent:		
Soil	5	5
Pennsylvanian:		
Kansas City formation:		
Clay, blue	15	20
Limestone	10	30
Shale, light	10	40
Shale, blue	40	80
Limestone, very hard (Bethany Falls and Winterset)	50	130
Shale, blue	2	132
Coal (black shale)	3	135
Limestone, white (Hertha)	20	155
Pleasanton formation:		
Shale, blue	45	200
Shale, light	68	268
Shale, blue	15	283
Shale, light	20	303
Rock, red	5	308
Limestone, very hard	10	318
Shale, blue	30	348
Henrietta and Cherokee:		
Limestone, very hard	9	357
GAS SAND	10	367
Shale	5	372
Limestone, hard	10	382
GAS SAND	8	390
Shale, light	12	402
Sand, water	10	412
Shale, dark	7	419
Shale, bituminous	5	424
Shale, light	15	439
OIL SAND	20	459

RECOMMENDATIONS FOR DRILLING.

As stated before in this report it is not the intention herein to predict the results of future drilling in the area. It is believed however from the evidence in hand that the prospects for finding such supplies of gas as obtained near Belton and Martin City are excellent in many localities over a considerable area and that even stronger supplies may be obtained from the same or other sandstone horizons in the Cherokee shale. It is also believed that the prospects for finding oil similar in quality and quantity to that in the Mastin Ranch wells are good in a number of localities and that even greater amounts may be found in the same or other sandstones in the Cherokee shale. It seems hardly reasonable to expect oil wells of large individual production and it is probable that any successful development will be the result of a group of relative shallow wells of small pro-

duction. The region is therefore considered worthy of some conservative drilling guided by the structural features shown on the map accompanying this report.

The Belton Anticline.

Previous drilling on this structure has been restricted to Secs. 1, 2 and 14, Twp. 46 N., and Sec. 36, Twp. 47 N., on the southern part and on the northeast flank of the anticline. There is thus a considerable area on the crest and especially on the north, northwest, and west flanks which remains to be tested. The NE. ¼, Sec. 10, Twp. 46 N., with the adjoining parts of the surrounding quarters are situated on the crest of the structure and should, if the oil and gas sands are persistent or present, afford a most favorable area for drilling. Secs. 3, 4 and 9, Twp. 46 N., include territory on the north and west flanks favorable for prospecting these parts of the anticline. On the east of section 10 both sections 11 and 12 have good locations upon the structure as also has the west ½ of section 13, and a considerable part of Sec. 24, Twp. 46 N. Those familiar with the interpretation of structural maps will of course draw their own conclusions as to the respective merits of any or all of these localities. For those unfamiliar with such maps, it may be stated that Secs. 10 and 13, Twp. 46 N. with at least the eastern halves of sections 4 and 9 appear to deserve preference because of their location either on the top or well up in the northern or western untested flanks of the anticline. Other localities however may prove equally as good or better. It is estimated that about 850 feet of drilling will be required to reach the base of the Pennsylvanian deposits beneath Sec. 10, Twp. 46 N.

The Jaudon Anticline.

The Jaudon anticline is absolutely untested so far as is known. This is one of the most pronounced structures within the area and though not quite so large as the Belton anticline, appears to present equally good possibilities. The highest points on the structure are located chiefly in the SE. ¼ of Sec. 33, Twp. 45 N. NE. ¼ Sec. 4, Twp. 45 N., and the NE. W. and SW. ¼ of Secs. 9, 10 and 3, Twp. 45 N., respectively. These localities should receive preference in the initial prospecting and should the drilling here justify, the areas should be extended.

In drilling the minor anticlines mentioned, locations should be chosen on the tops of the structures first. Further testing should be guided by the results of these wells.

Conditions to Be Considered in Drilling.

Great care was maintained in observing the variation in thickness of the shales, especially those of the Chanute, but over wide areas this was impossible, owing to the nature of outcrops. Since the folding is so gentle and the possible variation in thickness of that part of the rock section represented by the shales of the Kansas City formation, so comparatively great, serious discrepancies may occur between the structure of the datum plane (base of the Iola limestone) and the lower beds. The results of such discrepancies, if they do occur, may greatly impair the value of the structural conditions as represented by the key bed. The principal affect would be to cause a difference in location between the high points on the structures as shown by the map and the actual high points of the underlying sands. To just what extent such discrepancies may exist, if they do exist, cannot be foretold from the evidence available.

A second factor of great importance affecting the success of a well at any given location, is the nature of the "sands" encountered. As stated before, the sandstones of the Cherokee shale at least are extremely variable in character from place to place and may within short distances pinch out or grade laterally into a shale. Both this and the previously mentioned possible condition must be taken into consideration in anticipating the results of any drilling within the area.

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